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[Designation of Document] Claims

1. A method for manufacturing a high carbon thin steel sheet, characterized in that a steel strip having a steel composition comprising, in percent by weight,

C of 0.30 to 1.20%, Si of 1.00% or less,

Mn of 1.50% or less, P of 0.050% or less,

S of 0.050% or less, Sb of 0.01 to 0.10%

and Fe and inevitable impurities as the remainder,

is hot-rolled, then wound in a temperature range of 450°C or more and cooled, and then subjected to softening annealing in a temperature range of 600 to (Ac_1+40)°C or 600 to (Ac_{cm}+40)°C without descaling.

2. The method for manufacturing a high carbon thin steel sheet according to claim 1, characterized in that after the softening annealing, one or several times of cold rolling and annealing are further performed.

3. The method for manufacturing a high carbon thin steel sheet according to claim 1 or claim 2, wherein the steel strip further contains one or at least two of alloy components of Cr of 1.50% or less, Mo of 0.50% or less, and Ni of 0.20% or less.

[Designation of Document] Specification

[Title of the Invention]

Method for Manufacturing High Carbon Thin Steel Sheet

[Technical Field]

[Industrial Applicability]

The invention relates to a method for manufacturing a high carbon thin steel sheet having excellent decarbonization resistance. In further detailed description, the invention relates to a method for manufacturing a high carbon thin steel sheet which can effectively inhibit decarbonization in a sheet surface layer occurring in a heat treatment process such as spheriodizing annealing necessary for softening, quenching and tempering for adding intended strength, or austempering in a manufacturing process of a high carbon thin steel sheet; and is extremely effective for rationalization in manufacture of a high hardness member such as gear, washer, and cutter.

[Background Art]

Generally, for a high hardness component such as gear, washer, cutter, saw, or dip plate, a steel type having an extremely high C component of a low Mn series such as SK7M to SK1M defined in JIS G3311, or a high carbon cold-rolled steel sheet such as S45CM to S70CM is used as material.

In the method for manufacturing the material, a hot-rolled steel sheet is subjected to acid cleaning, and then subjected to annealing as needed, and formed into a product as a hot-rolled sheet, or further subjected to cold rolling and subsequent spheriodizing annealing to be adjusted to have appropriate strength. Typically, products obtained by punching and forming these are hardened by later heat treatment

such as quenching and tempering before use.

Here, since a raw-material steel sheet for each of the products is required to be soft and easy to be machined before forming, and have desired strength only by heat treatment after forming, and exhibit sufficient hardness and wear resistance for use as a product, typically a material having high C content is selected.

[Disclosure of the Invention]

[Problems that the Invention is to Solve]

However, in the conventional material, since hardness of the hot-rolled sheet increases with increase in C content, the material has been largely restricted in formability in processing into product or reduction rate in cold rolling. Therefore, there have been many problems in a manufacturing process, including increase in annealing time, and increase in number of cold rolling or annealing. Thus, the inventers tried to refine a structure of the hot-rolled sheet for the purpose of improvement in formability of the hot-rolled sheet and improvement in reduction rate in cold rolling, consequently recognized necessity of softening in the hot-rolled sheet.

To meet the two issues, rapid cooling after finish rolling in a hot rolling process and annealing of the hot-rolled sheet are necessary. However, since hardness of the hot-rolled sheet increases due to the rapid cooling after rolling, acid cleaning before annealing becomes difficult,

which has been a problem. Thus, the inventors have made investigation on means for performing softening annealing without descaling of the hot-rolled sheet by acid cleaning.

In the annealing, a process of box annealing is generally used, in which soaking is carried out for a long time of 6 to 24 hr at a temperature range of (Ac_1-50) to Ac_1°C, or Ac_1 to (Ac_1+30)°C. In this way, an inactive atmosphere such as N_2 or Ar, or a carburizing atmosphere such as coke gas or methane is used as an atmosphere, and the atmosphere gas is carefully selected for preventing decarbonization. However, even in such an atmosphere, a decarbonization layer is formed in a sheet surface layer due to scales adhered thereon, which has been a problem.

The following two reasons can be considered for decarbonization from the sheet surface layer during the heat treatment processes.

First, when oxidation scales in the hot rolling process are remained on the sheet surface layer, FeO_x as a main component of the scales is decomposed during soaking, thereby O_2 is generated and separated from the sheet surface layer. Residual scales are changed into pure iron, and thus the decarbonization layer is formed on the sheet surface layer.

Second, when O_2 temperature in atmospheric gas increases, O_2 is separated into O atoms in the sheet surface layer, and enters the inside from the sheet surface layer. The O atoms

are coupled with C in the sheet surface layer, thereby CO or CO_2 is formed and discharged outside from the sheet surface layer. Then, the decarbonization layer is formed.

The decarbonization layer formed in this way reduces hardness of a sheet surface and extremely degrades wear resistance, in addition, causes decrease in strength, therefore much attention must be paid to generation of the decarbonization layer.

Based on such a circumstance and the described request for cost reduction in the manufacturing process of tool steel, the inventors have recognized that, to respond the request, development of a steel type in which the material itself can be effectively inhibit the decarbonization is necessary.

Here, the invention intends to provide a method for manufacturing a high carbon thin steel sheet having excellent decarbonization resistance.

[Means for Solving the Problems]

Thus, to achieve the object, the inventors have been made various investigation on means for improving the formability or reduction rate in cold rolling, as a result, obtained the following, new findings on inhibition of increase in hardness in a structure of the hot-rolled sheet and during a process of forming the structure, in addition, prevention of decarbonization during the measure process.

(a) To obtain a fine structure in the hot-rolled steel,

winding in a comparatively low temperature range of 450°C or more is necessary after hot rolling.

(b) Furthermore, a hot-rolled sheet having such a fine structure generally has high hardness, therefore softening annealing is necessary by reheating the sheet in an appropriate temperature range of 600°C or more as needed after hot rolling is completed.

(c) Since the decarbonization layer is formed in the sheet surface layer in the conventional hot-rolled sheet by such reheating, in the invention, Sb of 0.01 wt% or more has been added to a steel sheet, and once the steel sheet is rolled into a thin steel sheet, since the contained Sb inhibits decomposition of O_2 gas into O atoms in a surface layer during heating such as annealing or quenching, entering of the O atoms into the sheet surface layer is prevented and reaction of C with O is inhibited in the sheet surface layer, therefore decarbonization is effectively prevented.

(d) Such a decarbonization prevention effect by Sb is effective for not only a general high carbon steel sheet generally called SC material or SK material in JIS standard, but also a low-alloy high carbon steel sheet of Cr-Mo series or Ni series.

(e) However, when Sb is heated to an austenite region, similarly as P or Sn, it has a property of segregating to austenite grain boundaries and reducing strength of old

austenite grain boundaries after cooling, and causing intergranular failure therein. Therefore, an upper limit is necessary for Sb loadings in the light of grain boundary reinforcement.

Based on the findings shown in the above (a) to (e), the inventors have made further investigation, as a result accomplished the invention.

Here, summary of the invention is a method for manufacturing a high carbon thin steel sheet characterized in that a steel strip having a steel composition comprising,

C of 0.30 to 1.20%, Si of 1.00% or less,

Mn of 1.50% or less, P of 0.050% or less,

S of 0.050% or less, Sb of 0.01 to 0.10%,

in percent by weight,

and further comprising one or at least two of alloy components of Cr of 1.50% or less, Mo of 0.50% or less, and Ni of 0.20% or less as needed,

and Fe and inevitable impurities as the remainder,

is hot-rolled, then wound in a temperature range of 450°C or more and cooled, and then subjected to softening annealing in a temperature range of 600 to (Ac_1+40)°C or 600 to (Ac_{cm}+40)°C without descaling, and further subjected to one or several times of cold rolling and annealing as needed.

[Operation]

Hereinafter, the invention is described in detail along

with operation and effects of the invention. In this specification, if not otherwise specified, "%" means "percent by weight".

First, the reason for limiting the composition of the steel strip used in the invention is described.

(a) C

C content needs to be 0.30% or more to add desired hardness and wear resistance to a steel sheet, on the other hand, when C of more than 1.20% is contained, since the amount of cementite increases, resulting in significant degradation in toughness, durability for a product is extremely hard to be secured. Therefore, C content was determined to be 0.30 to 1.20%.

(b) Si

Si needs to be added to add appropriate hardness for products, however, when Si of more than 1.00% is contained, the steel sheet becomes hard and tends to be embrittled. Therefore, Si content was determined to be 1.00% or less.

(c) Mn

Mn is generally added much to improve wear resistance in a wear-resistance steel sheet, and similarly in the steel sheet according to the invention, Mn is added for the same purpose with 1.50% as an upper limit. However, if it is added above the limit, since toughness of the steel is degraded, leading to damage of a product in use, Mn of more than 1.50% is not preferably added. Therefore, Mn content was determined

to be 1.50% or less.

Since decrease in the amount of Mn leads to degradation in hardenability, Mn of 0.30% or more is desirably added.

(d) P

P has large effects on toughness of a product after quenching and tempering by segregating to austenite grain boundaries of steel. It is natural that the P content is more preferable for toughness as it becomes lower. When the P content is more than 0.050%, P segregates to the grain boundaries, causing high possibility of intergranular embrittlement. Therefore, the P content was determined to be 0.050% or less, and desirably, it is limited to be 0.020% or less.

(e) S

While the amount of S is preferably small even in a typical steel sheet, particularly in a high strength steel sheet such as steel sheet according to the invention, MnS has a significant influence on degradation in toughness. Therefore, S content was determined to be 0.050% or less, and desirably, it is restricted to 0.020% or less.

(f) Sb

When high carbon steel is added with Sb of 0.01% or more, and rolled into a thin steel sheet, the contained Sb inhibits the decomposition of O_2 gas into O atoms in a surface layer during heating such as annealing or quenching, therefore

entering of the O atoms into the surface layer is prevented. Therefore, since reaction of C with O in the sheet surface layer is inhibited, decarbonization is effectively prevented.

However, when Sb is heated to the austenite region, similarly as P or Sn, it has a property of segregating to the austenite grain boundaries and reducing the strength of the old austenite grain boundaries after cooling, and causing the intergranular failure therein. Therefore, an upper limit of the Sb loadings needs to be restricted to 0.10% in the light of grain boundary reinforcement.

Therefore, the Sb loadings was limited to be 0.01 to 0.10%, however, Sb of about 0.02 to 0.08% is more desirably added in the light of securing effective inhibition of decarbonization or securing toughness.

Furthermore, the steel strip in the invention may be added with at least one of Cr, Mo and Ni as needed in addition to the composition. These are added for further improving mechanical properties such as hardenability and machinability of the steel according to the invention, and loadings of these and the reason for the loadings are individually described below.

(g) Cr

Cr is a component which is added as needed mainly for improving hardenability, however, when Cr of more than 1.50% is contained, hardening of the steel is caused, leading to

embrittlement. From the fact, in the steel strip used in the invention, Cr is added as needed for improving hardenability, and the upper limit is determined to be 1.50%. When improvement in hardenability is the purpose, it is desirable that Cr of 0.15% or more is intentionally added.

(h) Mo

Mo is a component which is added as needed, and addition of Mo gives an effect that high toughness after heat treatment is maintained without degrading machinability before the heat treatment (quenching and tempering) of the steel sheet.

Generally, when steel is tempered at a temperature of about 300°C after quenching, the steel is significantly embrittled because of occurrence of so-called "low-temperature temper embrittlement". Against the embrittlement, Mo is effectively added.

Therefore, in the steel sheet according to the invention, Mo is added with the upper limit of 0.50% as needed.

However, even if the upper limit is exceeded, the effect of improvement in toughness is saturated, and further cost increase is caused, therefore the upper limit is determined not to be exceeded.

To obtain the effect of improvement in toughness, Mo of 0.15% or more is desirably added.

(i) Ni

Ni is a component which has an effect of improving

machinability of steel, and is positively added as needed in the invention, however, Ni content is desirably 2.00% or less. Ni is effectively added to inhibit occurrence of a crack during rolling, furthermore, when the steel is machined by a user, facilitates the machining. This is considered to be because deformation resistance of a ferrite base phase is reduced.

On the other hand, even if Ni of more than 2.0% is added, only production cost of the steel sheet increases and the effect of improving machinability is saturated. Therefore, the upper limit of Ni loadings was established to be 2.0%.

In the invention, the steel strip having the composition is subjected to hot rolling and then wound, and then subjected to softening annealing in a particular temperature range without descaling. Hereinafter, the manufacturing conditions are described.

(j) From a viewpoint of perfectly dissolving cementite into austenite, it is desirable that hot rolling is performed in a temperature range of Ac_3 or Ac_{cm} point or more. Next, the steel sheet after the hot rolling in this way is wound in a temperature range of 450°C or more, and preferably 500°C or more, and then cooled. The reason for limiting the winding temperature in this way is that a fact that spheriodizing of cementite is efficiently advanced during annealing by refinement of a structure of an obtained hot-rolled sheet is utilized. Therefore, although a winding temperature

condition is more effective with lower temperature, since a difficulty such as occurrence of a crack due to hardening during winding occurs, the winding temperature wad limited to be 450°C or more. More preferably, it is 500°C or more. The upper limit of the winding temperature is desirably 650°C from a viewpoint of refinement of a structure of the hot-rolled sheet. According to knowledge of the inventors, increase in cooling rate during cooling after winding accelerates spheriodizing and refinement of cementite during annealing, therefore cooling rate is more desirable as it is larger.

(k) Temperature Conditions of Softening Annealing after Winding

As above, in the hot-rolled sheet wound at a comparative low temperature of 450°C or more, particularly in the case that cooling rate to the winding temperature is large, hardness is large, and a difficulty such as breaking may occur in the acid cleaning process before cold rolling or in the cold rolling process.

As a measure for preventing the difficulty, it is necessary that the hot-rolled sheet is heated to a temperature range of 600 to (Ac_1+40)°C or 600 to $(Ac_{cm}+40)$°C and then cooled without descaling by acid cleaning. This is because when annealing temperature is less than 600°C, both of hardness and critical compressibility are not improved, and when it is more than (Ac_1+40)°C or more than $(Ac_{cm}+40)$°C, since cementite is

precipitated lamellarly (in layer) during cooling, cold rolling is adversely affected.

In this case, the annealing is performed in an inactive atmosphere such as N_2 or Ar, or in a carburizing atmosphere such as coke gas or methane, or in the air as an atmospheric condition, and although the atmosphere gas is appropriately adjusted according to a condition of scale formation for preventing decarbonization, a selection condition of the gas is extremely wide compared with the conventional steel that is not added with Sb.

As a cooling condition after annealing, the steel sheet is desirably cooled at a comparatively slow rate of 100 °C/hr or less.

In this way, to the hot-rolled sheet subjected to softening annealing without descaling, in a typical case, after descaling by acid cleaning, one or several times of cold rolling and spheriodizing annealing are performed as needed. In this way, a high carbon thin steel sheet, which is extremely soft and has a large reduction rate compared with a steel sheet in the conventional case that the hot-rolled sheet is subjected to acid cleaning and then subjected to cold rolling, can be obtained.

[Best Mode for Carrying Out the Invention]

While the invention is further described in detail using embodiments, these are merely exemplification of the invention,

and are not intended to limit the invention.

First Embodiment

Steel strips No.A to No.G having chemical compositions as shown in Table 1 was subjected to hot rolling at a condition of,

finish rolling temperature of 850°C,

cooling rate of 50 °C/sec,

and winding temperature of 550°C;

and then subjected to annealing for soaking for 24 hr at each temperature of 650°C, 680°C, or 740°C with scales being remained. Heating/cooling rate in the annealing of the hot-rolled sheet was 40 °C/hr.

Table 1

Steel strip No.	C	Si	Mn	P	S	Sb	Ac_1 (°C)	Ac_{cm} (°C)	Legend	Remarks
A	0.35	0.18	0.81	0.021	0.010	0.014	805	-	○	Example of the invention
B	0.51	0.21	0.81	0.021	0.008	0.026	760	-	⊙	
C	0.65	0.20	0.79	0.028	0.008	0.041	745	-	●	
D	0.79	0.18	0.81	0.028	0.008	0.045	-	735	□	
E	1.01	0.20	0.82	0.029	0.009	0.051	-	820	■	
F	0.44	0.20	0.81	0.025	0.011	0.002*	775	-	×	Comparative example
G	0.98	0.19	0.81	0.025	0.011	0.005*	-	820	◆	

Note; * is without scope of the invention

Effects of Sb loadings on generation of the decarbonization layer from the surface layer (decarbonization depth from the surface layer) at that time are shown by graphs in Fig.1.

From the results, it was found that the steel strips No.A to No.E which were steel strips to which Sb was added within a scope according to the invention were suitable for

efficiently inhibiting decarbonization at respective temperature conditions.

Second Embodiment

The steel strips shown in Table 1 were subjected to hot rolling under the following condition, and then subjected to softening annealing without descaling, and subjected to acid cleaning after the softening annealing was completed. Change of hardness and change of critical reduction rate after annealing depending on annealing temperature of the hot-rolled sheet in this case were examined, and results were shown in Fig.2.

Hot rolling condition in the embodiment was as follow;

finish rolling temperature of 850°C,

cooling rate of 100 °C/sec,

and winding temperature of 500°C.

Heating/cooling rate in the annealing of the hot-rolled sheet was 40 °C/hr.

From the results, it is found that in annealing at a temperature of less than 600°C, hardness is too high, and critical reduction rate is extremely low. It was confirmed from the fact that softening and improvement in critical reduction rate were achieved by annealing in a temperature range of 600°C or more, which was within a scope of the invention.

Third Embodiment

The steel shown in Table 1 was similarly used to investigate effects of winding temperature conditions limited in the invention. Results are shown together in Fig.3.

In this case, hot rolling and annealing conditions were as follows;

finish rolling temperature of 850°C,

cooling rate of 100 °C/sec,

and hot-rolled sheet annealing condition of 680°C for 24 hr in nitrogen.

From the results, it was found that hardness after annealing decreased with lower winding temperature.

Although cooling rate after finish of hot rolling is not limited in the invention, as shown in Fig.4, it is found that softening is advanced after annealing with increase in cooling rate. In this case, hot rolling and annealing conditions were as follows;

finish rolling temperature of 850°C,

winding condition of winding at 500°C after cooling at each cooling rate,

hot-rolled sheet annealing condition of 680°C for 24 hr in nitrogen,

and heating/cooling rate of hot-rolled sheet of 40 °C/hr.

As described before, a cementite structure is refined, thereby spheriodizing in annealing advances more efficiently, and larger cooling rate is more desirable for such refinement

of cementite. Specifically, cooling rate of about 1 to 10 °C/sec is effective.

Fourth Embodiment

Steel types of steel strips No.J to No.Y shown in Table 2 were subjected to annealing after hot rolling without descaling according to a condition of the invention, subsequently subjected to cold rolling, and further subjected to finish annealing, resultantly thin steel sheets 2.5 mm thick were prepared. Hardness, absorbed energy, and decarbonization depth from the surface layer of the steel sheets after quenching and tempering were investigated. Results were shown in Table 2.

Table 2

Steel strip No.	Material chemical composition						Hardness (HRC)	Absorbed energy (kgf-m)	Decarbonization Depth in annealing (μm)	Remarks
	C	Si	Mn	P	S	Sb				
J	0.32	0.18	0.81	0.021	0.010	0.038	32.1	1.8	9	Example of the invention
K	1.15	0.21	0.81	0.210	0.008	0.025	39.2	0.6	3	
L	0.65	0.95	0.79	0.028	0.008	0.040	38.7	1.1	4	
M	0.64	0.18	1.47	0.028	0.008	0.045	40.3	1.2	2	
N	0.65	0.20	0.82	0.043	0.009	0.050	34.1	0.8	5	
O	0.63	0.20	0.81	0.025	0.043	0.045	33.8	0.9	4	
P	0.67	0.19	0.81	0.025	0.011	0.012	31.9	1.3	8	
Q	0.64	0.17	0.79	0.028	0.012	0.091	35.2	1.0	0	
R	*0.25	0.18	0.81	0.021	0.010	0.015	30.8	2.4	18	Comparative example
S	*1.49	0.21	0.81	0.022	0.008	0.025	40.1	0.4	3	
T	0.65	*1.54	0.79	0.028	0.008	0.040	39.2	0.7	6	
U	0.64	0.18	*2.21	0.028	0.008	0.045	41.4	0.6	2	
V	0.65	0.20	0.82	*0.054	0.009	0.050	35.0	0.6	8	
W	0.63	0.20	0.81	0.025	*0.061	0.045	34.4	0.6	9	
X	0.67	0.19	0.81	0.025	0.011	*0.002	31.2	1.6	21	
Y	0.64	0.17	0.79	0.028	0.012	*0.145	35.8	0.4	0	

note 1; quenching and temperature condition: 860°C for 30 min, OQ, and 400°C for 45 min
hot-rolled sheet annealing: 680°C for 24 hr (heating/cooling at 40 °C/hr)
Charpy test: JIS 4 V notch, sheet thickness of 2.5 mm

note 2: * is without scope of the invention

As shown in the results, it was found that the steel sheets obtained from the method according to the invention were excellent in both the absorbed energy and the inhibition of decarbonization compared with comparative examples.

Furthermore, in the case that one or at least two of alloy components of Cr of 1.50% or less, Mo of 0.50% or less, and Ni of 2.00% or less were contained, the test was similarly performed, and similar effects on the absorbed energy and the inhibition of decarbonization as in the embodiment were confirmed.

[Advantage of the Invention]

The invention is configured as described hereinbefore, thereby exhibits the advantage that the spheriodizing annealing necessary for softening of material, and the quenching and tempering for adding intended strength, or austempering can be performed while surface decarbonization is effectively inhibited, and is extremely useful in industry.

[Brief Description of the Drawings]

Fig.1 is a graph showing a relation between Sb loadings and decarbonization depth;

Fig.2 is a graph showing a relation between annealing temperature and critical reduction rate or hardness after hot-rolled sheet annealing;

Fig.3 is a graph showing a relation between winding temperature and critical reduction rate or hardness after

hot-rolled sheet annealing;

and Fig.4 is a graph showing a relation between cooling rate and critical reduction rate or hardness after hot-rolled sheet annealing.

Fig.1

第1図

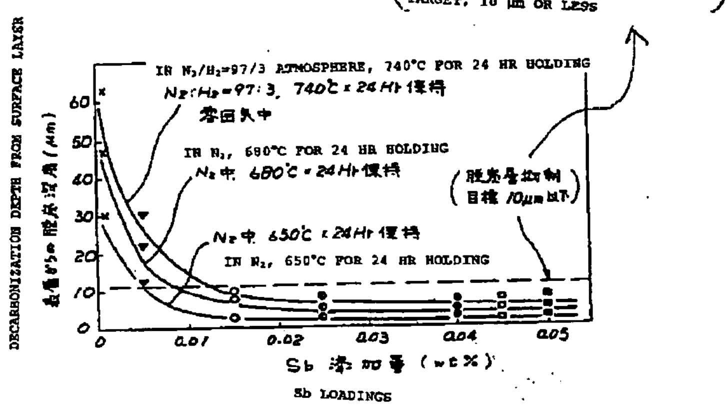

Fig.2

第2図

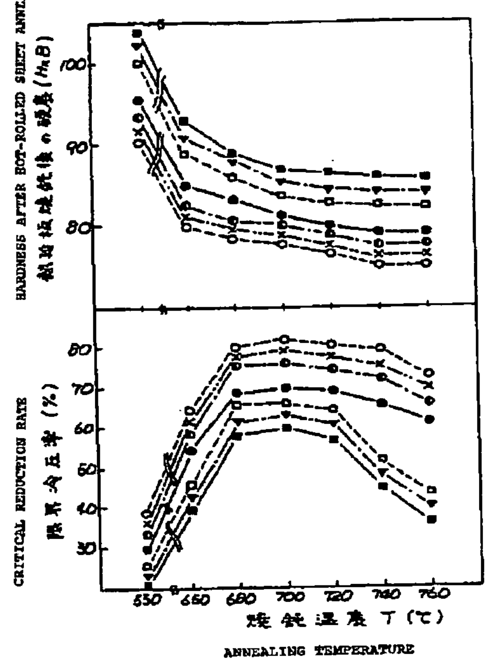

Fig.3

第3図

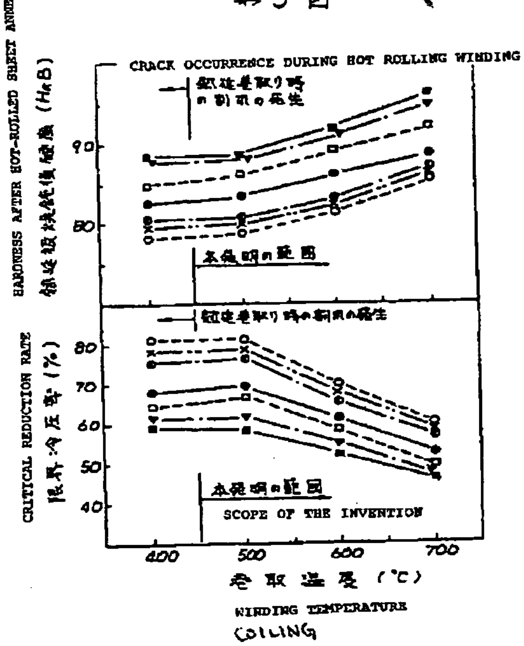

Fig.4

第4図

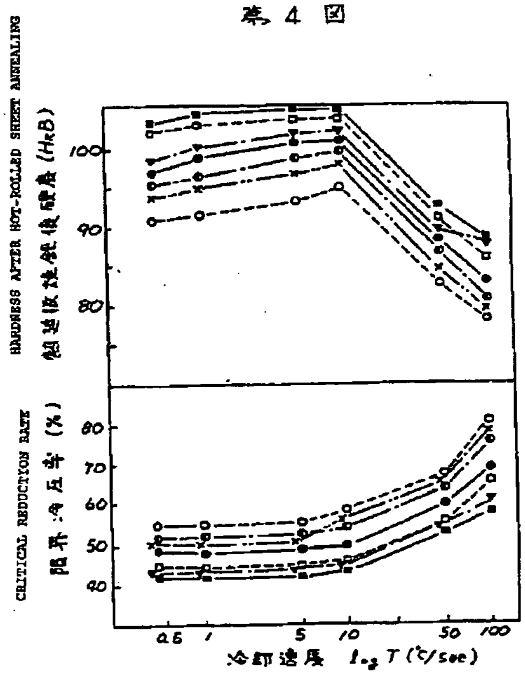

Fig.1

DECARBONIZATION DEPTH FROM SURFACE LAYER

Sb LOADINGS

IN N_2/H_2=97/3 ATMOSPHERE, 740°C FOR 24 HR HOLDING

IN N_2, 680°C FOR 24 HR HOLDING

IN N_2, 650°C FOR 24 HR HOLDING

DECARBONIZATION LAYER RESTRICTION TARGET, 10 μm OR LESS

Fig.2

HARDNESS AFTER HOT-ROLLED SHEET ANNEALING

CRITICAL REDUCTION RATE

ANNEALING TEMPERATURE

Fig.3

HARDNESS AFTER HOT-ROLLED SHEET ANNEALING

CRITICAL REDUCTION RATE

WINDING TEMPERATURE

CRACK OCCURRENCE DURING HOT ROLLING WINDING

SCOPE OF THE INVENTION

Fig.4

HARDNESS AFTER HOT-ROLLED SHEET ANNEALING

CRITICAL REDUCTION RATE

COOLING RATE

L35: Entry 3 of 5 File: JPAB Feb 26, 1991

PUB-NO: JP403044422A
DOCUMENT-IDENTIFIER: JP 03044422 A
TITLE: MANUFACTURE OF HIGH CARBON THIN STEEL SHEET

PUBN-DATE: February 26, 1991

INVENTOR-INFORMATION:

NAME	COUNTRY
FUKUI, KIYOSHI	
OKAMOTO, ATSUKI	

INT-CL (IPC): C21D 9/46; C21D 8/02; C22C 38/00; C22C 38/60

ABSTRACT:

PURPOSE: To stably manufacture the high carbon steel sheet for a high hardness member having effectively suppressed decarburizing reaction on a surface layer, at the time of manufacturing the high carbon thin steel sheet, by subjecting a hot rolled sheet of a high carbon steel to softening in a specified temp. area without executing descaling and, if required, thereafter subjecting it to cold rolling and annealing.

CONSTITUTION: A medium-high carbon slab having the compsn. contg., by weight, 0.30 to 1.20% C, <1.0% Si, <1.50% Mn, <0.050% P, <0.050% S and 0.01 to 0.10% Sb or furthermore contg. one or more kinds among <1.50% Cr, <0.50% Mo and <2.0% Ni is hot rolled into a hot rolled sheet, which is thereafter coiled at ≥450°C and is subjected to air cooling. Since the decarburization on the surface of the hot rolled sheet can effectively be prevented by the incorporation of Sb, descaling can be unnecessitated. Then, the sheet is subjected to softening in the temp. area of 600 to (Ac1+40)°C or 600 to (Ac +40)°C and, if required, is furthermore subjected to one or plural times of cold rolling and annealing. Its decarburization at the time of heat treatment such as spheroidizing needed for the softening and quenching, tempering and austempering for improving the strength can effectively be suppressed, by which the high hardness steel sheet can stably be manufactured.